Theory of cooperative emission from quantum dots

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Abstract

Collective light-matter coupling, leading to enhanced transition rates and altered photon statistics, has many potential applications in future quantum technologies. Quantum dots are a promising solid-state platform for collective effects due to their excellent light emission properties. Recently, collective emission from up to three quantum dots has been observed experimentally (Grim et. al., Nat. Mater, 2019; Tiranov et. al., Science 2023).
As a solid-state platform, quantum dots suffer from spectral inhomogeneity, a low emitter density and decoherence, mainly due to lattice vibrations. Thus, a meticulous theoretical understanding of collective effects in noisy systems is needed to disambiguate different types of collective effects and to address questions about noise robustness.
This contribution presents a theoretical perspective on collective emission from quantum dots. I will introduce two distinct collective emission phenomena, namely measurement-induced collective emission and superradiance. Also, the impact of phonons, which are treated on the polaron master equation level, as well as utilizing state-of-the art process tensor methods, will be addressed (Wiercinski et. al. PRR 2023, Wiercinski et. al. PRR 2024).

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